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The Transmission of Gun and Other Weapon-Involved Violence Within Social Networks

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Fatal and nonfatal injuries resulting from gun violence remain a persistent problem in the United States. The available research suggests that gun violence diffuses among people and across places through social relationships. Understanding the relationship between gun violence within social networks and individual gun violence risk is critical in preventing the spread of gun violence within populations. This systematic review examines the existing scientific evidence on the transmission of gun and other weapon-related violence in household, intimate partner, peer, and co-offending networks. Our review identified 16 studies published between 1996 and 2015 that suggest that exposure to a victim or perpetrator of violence in one's interpersonal relationships and social networks increases the risk of individual victimization and perpetration. Formal network analyses find high concentrations of gun violence in small networks and that exposure to gun violence in one's networks is highly correlated with one's own probability of being a gunshot victim. Physical violence by parents and weapon use by intimate partners also increase risk for victimization and perpetration. Additional work is needed to better characterize the mechanisms through which network exposures increase individual risk for violence and to evaluate interventions aimed at disrupting the spread of gun and other weapon violence in high-risk social networks.

crime victims; domestic violence; family; firearms; homicide; peer group; spouses; violence

Abbreviations: aOR, adjusted odds ratio; CI, confidence interval; IPV, intimate partner violence.

INTRODUCTION

Despite reductions in gun-related homicide rates over the last 2 decades, gun violence remains a major contributor to morbidity and mortality in the United States. In 2013, for example, over 11,000 individuals died in a firearm-related homicide, with an additional 62,000 experiencing nonfatal firearm-related injuries in violent assaults (1). Public health researchers, criminologists, and other scholars have examined the various causes, correlates, and consequences of gun violence, as well as how such information might be used to guide intervention and prevention efforts (2–4). One reoccurring theme in this research is the epidemiologic idea that gun violence can be transmitted from one person, community, group, or population to another (5, 6). That is, gun violence can and does diffuse in a population through exposure, leading to some of the observed epidemic-like patterns. The transmission of gun violence is suggested to occur through interpersonal relationships or networks—the social, behavioral, friendship, kinship, and other types of ties that link individuals and groups (7, 8).

This systematic review aims to summarize the available empirical evidence on the transmission of gun violence within social networks. In particular, we review studies that examine how exposure to a victim or perpetrator of violence in one's social network influences one's own individual risk of victimization or perpetration. Because the adaptation of formal network models within public health and epidemiology is still a relatively new endeavor (7, 9, 10), we define "social networks" both broadly with respect to familial, domestic, and interpersonal relationships and specifically in terms of formally measured social and behavioral ties among individuals. Gun carrying emerged as a closely related concept discussed in many eligible studies; as such, we include a brief narrative review of relevant gun-carrying studies to further explore links between network exposures and risk of violence. Our findings are followed by a discussion of the transmission mechanisms suggested by the reviewed studies, the

limitations of existing studies of the estimated effects of exposure to violence within networks, and the policy implications of available research for gun violence prevention and intervention efforts.

METHODS

We reviewed the literature for all studies that presented empirical data on the relation between exposure to victims or perpetrators of violence in one's social network (defined as family, intimate partners, friends or peers, and co-offenders) and experiences of individual victimization or perpetration. To be eligible for the review, studies had to include an "exposure" measure of violent victimization or perpetration by a defined social network member (i.e., a parent, intimate partner, friend, or associate) and an "outcome" measure of individual victimization or perpetration. We originally intended to restrict our review to studies of the transmission of gun violence; however, we discovered that there were only 3 studies in which both the exposure and outcome were specific to gun violence. Therefore, we expanded our review to include studies in which either the exposure or outcome measure or both were specific to gun or other weapon-related violence, including threats of or actual use of a weapon like a gun or knife. This more inclusive search allowed us to identify papers that, although not specific solely to the transmission of gun violence, nevertheless provide insight into the generation and consequences of serious weapon-related violence within social networks, including networks not defined by criminal involvement.

Citations from the following databases were identified: PubMed, Web of Knowledge (including the Science Citation Index, Social Science Citation Index, and Medline), Social Sciences Full Text, Sociological Abstracts, Criminal Justice Abstracts, National Criminal Justice Reference Service Abstracts, and Proquest Criminal Justice. We used the search terms "gun," "firearm," and "weapon" in combination with terms related to violence and violent behaviors ("violence," "victimization," "perpetration," "injury," "homicide") and network classifications and transmission processes ("network," "peer," "friend," "gang," "family," "household," "parent," "maternal," "paternal," "sibling," "spouse," "partner," "domestic," "intergenerational," "transmission," "contagion"). We also reviewed the bibliographies of identified studies to obtain additional articles for inclusion and considered relevant articles in press at the time of the search that were known to the authors. Time restrictions were not placed on the search; however, we did restrict to English-language papers. In total, 16 articles met our inclusion criteria and were included in this review (Figure 1). Common reasons papers were excluded from the systematic review included providing only descriptive information about the prevalence of violence exposure in a particular population, presenting information only about gun carrying or gun ownership, and including only composite measures of violence or delinquency rather than assessing gun or weapon violence in particular. We also note that we excluded papers that only assessed exposure to community or school violence (e.g., personally witnessing or hearing about someone in one's neighborhood being shot), as well as those that included measures of personal victimization exposure without specifying a particular perpetrator, as our goal was to focus on the particular links between individuals through which violence may be transmitted.

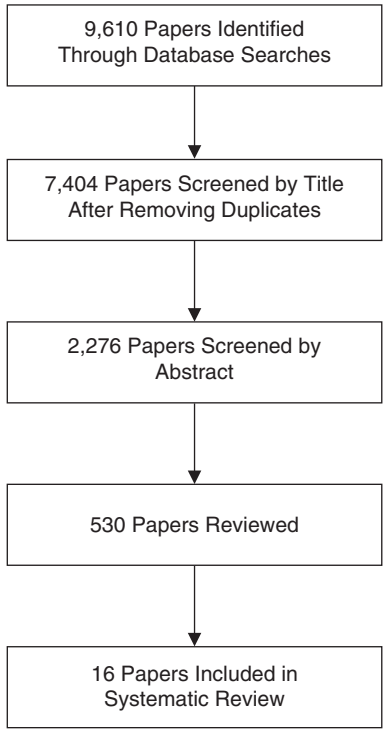

Figure 1. Flowchart of the selection of studies to include in the systematic review.

RESULTS

The 16 studies included in this review are summarized in Table 1. All 16 studies were published in peer-reviewed journals between 1996 and 2015 and were conducted in the United States, except for 1 study conducted in Canada (11) and 1 conducted in Scotland (12). Two studies included only men, and 3 studies included only women. One study assessed violence among children, and 4 studies were limited to adolescents, while the rest were conducted among adults, including 1 utilizing a community-based sample, 7 studies restricted to individuals with a history of intimate partner violence (IPV), and 6 studies relying on police records regarding arrests or gang membership. Six studies presented estimates of the risk of violence transmission between family members, 6 between intimate partners, 1 among peers, and 3 within co-offending networks. Within these network classifications, 4 types of violence relations were possible: 1) victimization of a network member influencing individual victimization; 2) victimization of a network member influencing individual perpetration; 3) perpetration by a network member influencing individual victimization; and 4) perpetration by a network member influencing individual perpetration.

Table 1. Studies of the Relationships Between Exposure to a Victim or Perpetrator of Violence in One's Social Network and Individual Risk of Violent Victimization or Perpetration

First Author, Year (Reference No.)	Type of Violence Transmission	Sample			Age	Network Violence Exposure	Violent Outcome	Data Collection Methods	Analytical Methods	Key Findings
		No.	Location	Population						
Murphy, 2011 (13)	Violent perpetration by parents → weapon victimization	2,898	United States	Young adults who completed all 3 waves of the National Longitudinal Study of Adolescent Health (Add Health) and who had been in a heterosexual romantic relationship for at least 3 months at the time of the wave III interview	Range, 18–26 years	Parents or other adult caregiver(s) slapped, hit, or kicked the respondent before sixth grade	Victim of weapon violence in the past 12 months (someone shot, cut or stabbed, pulled a knife or gun on, or jumped the respondent)	Participants self-reported the exposure and outcome during the wave III in-home interviews	Logistic regression model adjusted for ethnicity; sex; age; educational attainment; history of sexual abuse and neglect (left home alone, needs not met) before grade 6; and prior victimization (reported at waves I and II)	Physical violence perpetration by parents in childhood was associated with increased odds of weapon victimization in young adulthood (adjusted OR = 1.51) ($P < 0.001$)
Tucker, 2014 (14)	Violent perpetration by parents → weapon victimization	1,726	United States	Children with at least 1 sibling under age 18 years, from nationally representative sample interviewed in the National Survey of Children's Exposure to Violence	Range, 2–9 years	Witnessed violence perpetrated by parent against other parent, sibling, or another adult in the household in the past year	Victim of severe physical assault (involving a weapon or causing injury) by a sibling in the past year	Adult caregivers reported the exposure and outcome for 1 randomly selected child in the household during telephone interviews	Logistic regression model adjusted for child's race/ethnicity, age, and sex; parent or partner's highest education level; parent's marital status; parent warmth; parent inconsistency/ hostility; parent supervision; and interparental conflict	9% of children in the sample had been exposed to parent perpetration of violence; 3% had been severely victimized by a sibling. Witnessing parent perpetration of violence was associated with increased odds of severe victimization by a sibling (adjusted OR = 3.22, 95% CI: 1.53, 6.75) compared with no sibling victimization
Murrell, 2005 (15)	Weapon perpetration by parents → weapon perpetration	362	United States	Male batterers who were court ordered to receive assessment at a domestic violence assessment center, and who had nonmissing data on threatened or actual weapon use	Range, 18–65 years	Witnessed threatened or actual use of a gun or knife by either parent before the age of 16 years	Threatened or actual use of a gun or knife against an intimate partner	Men self-reported the exposure and outcome on written questionnaires. Reports of weapon use by the men against their partners in domestic violence incidents were verified from court records	χ^2 analysis unadjusted for other covariates	7% of the sample reported witnessing a parent threaten to use or actually use a weapon against an intimate partner; 57% reported threatening or actually using a weapon against an intimate partner themselves. A greater proportion of men who had witnessed parental weapon use during childhood reported threatened or actual weapon use against an intimate partner (83% vs. 55% of men without a witnessing history, $P < 0.01$)

Table continues

Table 1. Continued

First Author, Year (Reference No.)	Type of Violence Transmission	Sample			Age	Network Violence Exposure	Violent Outcome	Data Collection Methods	Analytical Methods	Key Findings
		No.	Location	Population						
Khan, 2008 (12)	Violent perpetration by parents → weapon perpetration	111	Scotland	Youth offenders who had been or were currently under the care of the Scottish youth criminal justice or welfare system	Range, 10–19 years (mean = 14.83 years)	Witnessed violence perpetrated by parent(s)	Perpetration of severe violence against a sibling with threats of or actual weapon use	Youth self-reported the exposure and outcome during interviews	Regression model unadjusted for other covariates	36.9% of participants had witnessed or were aware of weapons being used during interparental assaults; 30.6% of participants reported having ever threatened a sibling with a knife, 19.8% wounded a sibling with a knife, 19.8% threatened a sibling with a gun, and 9.9% fired a gun at a sibling Witnessing parent perpetration of violence was associated with severe violence with a weapon perpetrated against a sibling ($\beta = 0.24$, $t = 2.34$, $P = 0.022$)
Casiano, 2009 (16)	Violent perpetration by family member → gun and other weapon perpetration	5,692	United States	Adults representative of the noninstitutionalized civilian population, from the National Comorbidity Survey-Replication	Range, ≥18 years	Witnessed serious physical fights at home, such as father beating up mother, at age 16 or younger	Ever threatened someone with a gun or with another type of weapon, such as a knife, stick, broken bottle, or mace	Participants self-reported the exposure and outcome during interviews	Logistic regression model adjusted for sex, age, race, education, marital status, employment status, income, urbanicity, lifetime mental disorders, childhood physical abuse, and childhood sexual abuse. Separate models were fit for each outcome (threats with a gun and threats with another weapon)	13.1% of the sample reported witnessing domestic violence during childhood; 3.5% and 6.3% reported ever threatening someone with a gun or with another weapon, respectively. Witnessing domestic violence during childhood was associated with having threatened others with a gun (adjusted OR = 2.62, 95% CI: 1.8, 3.8) and with having threatened others with another weapon (adjusted OR = 1.34, 95% CI: 1.0, 1.8)
Vaughan, 1996 (17)	Gun victimization of family or friends → weapon perpetration	2,005	New York, New York	Boys and girls in 3 junior high schools	Range, 11–15 years (students in 7th and 8th grades; mean = 12.8 years)	Close friend or family member was victim of a shooting	Used a weapon on someone	Youth self-reported the exposure and outcome on written questionnaires	Logistic regression model unadjusted for other covariates	41.5% of students reported that a close friend or family member had been shot; 24.0% and 14.0% of boys and girls, respectively, reported having ever used a weapon on someone. Reporting that a close friend or family member had been shot was associated with reporting having used a weapon on someone (OR = 2.8, 95% CI: 2.1, 3.6)

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Table 1. Continued

First Author, Year (Reference No.)	Type of Violence Transmission	Sample			Age	Network Violence Exposure	Violent Outcome	Data Collection Methods	Analytical Methods	Key Findings
		No.	Location	Population						
Roberts, 1996 (29)	Weapon perpetration by intimate partner → homicide perpetration	105 homicide perpetrators and 105 abused controls	New Jersey	Abused women who killed their partner or former partner and were in prison and abused control women selected from suburban police departments and battered women's shelters	Not available	Weapon used by intimate partner in worst incident of domestic violence	Killed intimate partner	Women reported the exposure during in-person structured and open-ended interviews	Proportions unadjusted for other covariates	A greater proportion of women who killed their intimate partner reported weapon use by the partner (39.7% vs. 18.8% of abused women in the control sample)
Campbell, 2003 (30)	Gun and other weapon perpetration by intimate partner → homicide victimization	220 femicide cases and 343 abused controls	11 cities in the United States	Femicide cases and control women who had been physically assaulted or threatened with a weapon by a current or former intimate partner during the past 2 years	Range, 18–50 years	Intimate partner had ever threatened the victim with a weapon and/or had used a gun in the most severe incident of abuse	Homicide by intimate partner	For femicide cases, proxy informants who were knowledgeable about the victim's relationship with the perpetrator reported on weapon threats and gun use during in-person or telephone interviews. Control women self-reported the exposure and outcome during telephone interviews	Logistic regression model adjusted for intimate partner employment status, partner and victim access to a gun, whether perpetrator and victim ever lived together, whether victim had a child by a previous partner in the home, partner's level of control over victim, whether partner had previously threatened to kill victim, whether partner had previously forced sex with victim, whether partner had previously been arrested for domestic violence, and characteristics of the most severe abuse incident (victim or perpetrators had used alcohol or drugs, and incident was triggered by victim leaving the perpetrator for another relationship)	55.3% of femicide cases vs. 4.7% of abused controls had been threatened with a weapon by their intimate partner; a gun was used in 38.2% and 0.9% of the most severe abuse incidents for femicide cases and abused controls, respectively. Intimate partner's previous threats with a weapon and use of a gun were associated with femicide (vs. control) status in adjusted models (adjusted OR for threats = 4.41, 95% CI: 1.76, 11.06; adjusted OR for use of gun = 41.38; $P < 0.01$)
Kingsnorth, 2006 (32)	Weapon perpetration by intimate partner → victimization	872	Sacramento County, California	Heterosexual couples with an intimate partner violence arrest that was closed by the district attorney's office between January 1, 2000, and April 30, 2000, filed as a misdemeanor or violation of probation, and for which information on critical variables was available	Not available	Weapon used in the index abuse incident	Rearrest for an intimate partner violence offense during the 18-month follow-up period after the index incident	Data on the exposure and outcome were obtained from law enforcement arrest and crime reports, California Department of Justice arrest histories, and prosecutor files, including victim services reports	Logistic regression model adjusted for suspect characteristics (any prior arrest, race/ethnicity, employment status, sex, age, substance use, marital status, cohabitation status, protective order in place) and incident characteristics (victim wanted arrest)	A weapon was used in 16.3% of the index abuse incidents; 15.3% of suspects were rearrested for intimate partner physical violence within 18 months of the index incident. Weapon use during the index incident was associated with increased odds of physical violence recidivism (adjusted OR = 2.14, $P < 0.05$)

Table continues

Table 1. Continued

First Author, Year (Reference No.)	Type of Violence Transmission	Sample			Age	Network Violence Exposure	Violent Outcome	Data Collection Methods	Analytical Methods	Key Findings
		No.	Location	Population						
Glass, 2008 (31)	Gun perpetration by intimate partner → victimization	84	United States	Women who reported current or past-year physical or sexual violence by a same-sex partner or former partner and who completed a 1-month follow-up interview	Mean = 36.59 (SD, 12.17) years	Intimate partner had ever threatened or used a gun against the victim	Reassault (physical or sexual) or threat of reassault in the past month by the partner or former partner	Women self-reported the exposure during baseline telephone interviews and the outcome during 1-month follow-up telephone interviews	Relative risk ratios unadjusted for other covariates	Threat or actual use of a gun by an intimate partner was reported by 14.7% of the sample; one third of the sample reported threatened or actual reassault at follow-up Intimate partner's previous threatened or actual use of a gun was associated with an increased risk for reassault (RRR = 1.93, 95% CI: 0.79, 4.75)
Folkes, 2013 (11)	Weapon perpetration by intimate partner → victimization	1,421	Ontario, Canada	Male offenders who had committed a physical assault or made a death threat against a wife or cohabiting female partner	Mean = 37.1 (SD, 11.1) years)	Intimate partner used or threatened to use a firearm or used a weapon in the index abuse incident	No. of occurrences of physical assault against a female partner that were recorded in police reports or criminal records after the index incident, and measures of severity of recidivism	Data on the exposure and outcome were obtained from occurrence reports filed by police in Ontario, Canada, as well as criminal records maintained by the Canadian Police Information Center.	Correlation analysis unadjusted for other covariates	3 men (0.2%) used a firearm in the index assault, whereas 21 men (1.5%) threatened to use a firearm. 88 men (6.2%) used a weapon (including a firearm) in the index assault. 32% of the men violently recidivated against a female partner after the index assault (with a mean follow-up of 5.4 years, SD, 1.43) The offender's weapon use in the index assault was not associated with physical assault recidivism ($r = 0.05$) or with measures of the severity of domestic violence recidivism ($r = -0.03$ to 0.02)
Bonomi, 2014 (33)	Weapon perpetration by intimate partner → victimization	5,994	Seattle, Washington	Couples who had a male-to-female perpetrated intimate partner violence incident reported to the Seattle Police Department during 1999–2001, with nonmissing census tract information for the location of the incident	Range, ≥18 years	Weapon involvement (guns, rifles, knives, or vehicles) in the index abuse incident	No. of police-reported physical abuse incidents during the 2-year period after the index incident, where physical abuse included assault, homicide, rape, reckless endangerment, and unlawful imprisonment	Data on the exposure and outcome were obtained from the Seattle Police Department's Domestic Violence Unit database, which includes information recorded by police officers responding to reported incidents.	Generalized estimating equation Poisson regression models were used to account for individuals nested within census tracts. Models were adjusted for characteristics of the index abuse event, including victim and perpetrator race/ethnicity and age; perpetrator drug and alcohol use; victim pregnancy; type of abuse (physical or nonphysical); victim injury; police arrest; and quartiles of neighborhood per capita income based on the census tract of the incident location	5.2% of the index abuse events included weapon involvement; 13% of women experienced physical intimate partner violence during the 2-year follow-up period. Weapon perpetration by a male intimate partner at the index abuse event was associated with 72% more physical abuse incidents during the follow-up period (adjusted IRR = 1.72, 95% CI: 1.29, 2.30)

Table continues

Table 1. Continued

First Author, Year (Reference No.)	Type of Violence Transmission	Sample			Age	Network Violence Exposure	Violent Outcome	Data Collection Methods	Analytical Methods	Key Findings
		No.	Location	Population						
Haynie, 2006 (46)	Violent perpetration by peers → weapon perpetration	12,747	United States	Adolescents who completed the in-school survey and first 2 in-home interview waves of the National Longitudinal Study of Adolescent Health (Add Health), who provided an address, and who had parents who completed the parent questionnaire and friends who completed the in-school survey	Mean = 15.8 years	Peer involvement in physical fights in the past 12 months	Serious violent behaviors in the past 12 months (pulled a knife or gun on someone, shot or stabbed someone, used a weapon in a fight, hurt someone badly enough to need medical care)	Participants were asked to identify up to 5 of their closest friends of each sex from a school roster; the friends' own responses from in-school surveys about physical fighting were averaged to create the exposure measure of peer violence. Serious violent behaviors were self-reported by the participants in the wave II in-home interviews	Hierarchical linear models were used to account for individuals nested within neighborhoods. Models were adjusted for neighborhood characteristics (disadvantage, residential instability, immigrant concentration, population size); peer school orientation; age and age squared; sex; race; family structure; family socioeconomic status; parent-child relationship quality; mother's age; parent reasons for selecting neighborhood; no friends identified by respondent; and respondent's own school orientation and fighting (from wave I).	11% of the sample reported serious violent behaviors in the past 12 months. Peer fighting was associated with serious violent behavior ($\beta = 0.18$ for a 1- SD increase in peer fighting; SD, 0.03)
Papachristos, 2012 (8)	Gun victimization of peers → gun victimization	763	Boston, Massachusetts	Individuals, including reported gang members and their associates, in the Cape Verdean community	Mean = 24.87 (SD, 6.33) years	Mean social distance between individual and gunshot victims in social network; percentage of immediate associates who were gunshot victims	Fatal or nonfatal gun victimization	Field intelligence observations from the Boston Police Department in 2008 were used to identify ties between individuals who were observed in each other's presence by police. A list of immediate associates of all Cape Verdean gang members known to the police was first created; another list of "friends" was then created from field intelligence observations on these associates. Records on all fatal and nonfatal gunshot injuries reported to the police in 2008–2009 were used to identify the outcome	Rare event logistic regression models adjusted for individual characteristics (sex, ethnicity, age squared, history of arrest) and network variables (ego-network density and percent of immediate associates who were gang members)	The average shortest distance to a gunshot victim was 4.69 ties (SD, 2.91), and the average percent of an individual's immediate associates who were gunshot victims was 8% (SD, 21%). 5% of the sample were victims of gun violence. The farther one is from a gunshot victim in one's social network, the lower one's own odds of gun victimization (adjusted OR = 0.91, 95% CI: 0.84, 0.99 for each social tie removed from a victim); having a greater percentage of immediate associates who were gunshot victims was associated with increased odds of gun victimization (adjusted OR = 2.44, 95% CI: 1.11, 5.36 for an increase of 1 percentage point)

Table continues

Table 1. Continued

First Author, Year (Reference No.)	Type of Violence Transmission	Sample			Age	Network Violence Exposure	Violent Outcome	Data Collection Methods	Analytical Methods	Key Findings
		No.	Location	Population						
Papachristos, 2014 (47)	Gun homicide victimization of co-offenders → gun homicide victimization	8,222	Chicago, Illinois	Individuals who were arrested between 2006 and 2011 in a high-crime community and who had co-offending ties to at least 1 other person	Mean = 27.4 (SD, 9.68) years	Mean social distance between individual and gun homicide victims in the co-offending network	Gun homicide victimization between 2006 and 2011	Arrest records from the Chicago Police Department were used to identify known co-offenders (i.e., ≥2 people arrested together for the same crime) and create co-offending networks. Homicide records from the Chicago Police Department were used to identify the outcome	Logistic regression models adjusted for individual characteristics (age, age squared, African-American race, sex, gang membership) and network characteristics (network degree (total no. of ties), ego density (proportion of individual's associates who were also tied to each other), whether an individual was a member of the largest network component, and geographical distance to the nearest homicide victim)	On average, any individual in the network was 5.4 ties away from a homicide victim; the average shortest path to a homicide victim of all possible paths was 10.53 ties (SD, 2.59). The farther one is from a gun homicide victim in the co-offending network, the lower one's own odds of gun homicide (adjusted OR = 0.42, 95% CI: 0.27, 0.65, for each social tie removed from a victim)
Papachristos, 2015 (48)	Nonfatal gun victimization of co-offenders → nonfatal gun victimization	169,725	Chicago, Illinois	Individuals who were arrested between January 1, 2006, and September 30, 2012, and who had co-offending ties to at least 1 other person	Mean = 25.7 years	Percentage of one's associates who are nonfatal gunshot victims	Nonfatal gunshot injury	Arrest records from the Chicago Police Department were used to identify known co-offenders and create co-offending networks. Data on nonfatal gunshot injuries from the Chicago Police Department were used to identify the outcome	Logistic regression models adjusted for individual characteristics (sex, age, gang member, race) and network characteristics (network degree and membership in the largest network component).	The average percentage of immediate associates who were victims of gunshot injuries was 6.3% (SD, 16.7%). Having higher percentages of one's associates who were nonfatal gunshot victims was associated with higher odds of nonfatal gunshot injury (e.g., OR = 3.13, SD, 0.06, for an increase in 1 percentage point of immediate associates who are gunshot victims).

Abbreviations: CI, confidence interval; IRR, incidence rate ratio; OR, odds ratio; RRR, relative risk ratio; SD, standard deviation.

Violence transmission among family and household members

Our systematic review identified several types of violence transmission between family and household members, including the intergenerational transmission of violence from parents to children (12–16) and the influence of gun victimization of family members on weapon use among adolescents (17). Together, these studies demonstrate a heightened risk for gun or other weapon victimization and perpetration at different stages of the life course among individuals who were exposed to violent perpetration or gun victimization among family members in childhood.

Violent perpetration by a family member as a risk factor for individual victimization. Two included studies found evidence of an association between exposure to violence perpetrated by parents and risk of weapon victimization by someone else. In the study of weapon victimization among participants in the third wave of the National Longitudinal Study of Adolescent Health (Add Health) by Murphy (13), retrospective self-reports of physical abuse perpetrated by parents against the participants themselves in childhood were associated with being threatened or injured with a gun or knife in the past year as a young adult (adjusted odds ratio (aOR) = 1.51). The authors also found associations between parent perpetration of physical abuse in childhood and risk of intimate partner victimization in young adulthood, though not weapon victimization specifically. Tucker et al. (14) examined a similar question among a national sample of younger children (aged 2–9 years) whose parent or caregiver reported on the child's experience of witnessing physical violence perpetrated by a parent against another household member, as well as the child's victimization by a juvenile sibling, classified into none, common (including mild physical aggression, stolen or ruined property, and psychological aggression), and severe (including weapon use). Witnessing parent perpetration of violence was associated with severe victimization by a sibling in adjusted multinomial logistic regression models (aOR = 3.22, 95% confidence interval (CI): 1.53, 6.75).

Violent perpetration by a family member as a risk factor for individual perpetration. Several included studies provided support for an association between exposure to violence perpetrated by parents during childhood and one's own violent behaviors. In Murrell et al. (15), 6.6% of a sample of men with a history of domestic violence reported having witnessed threatened or actual weapon use by either parent during their childhood, and more than half (57%) had threatened to or actually used a weapon against an intimate partner themselves, with reports verified from court records. The prevalence of weapon violence in this sample was very high given their history of IPV, yet the study indicated that weapon violence against intimate partners was more common among those with parental weapon violence exposure than those without (83% vs. 55%), although this finding may be confounded by other correlates of violence and also did not consider different levels of violence frequency.

Khan and Cooke (12) interviewed a young sample of juvenile offenders (aged 10–19 years) about their exposure to physical violence between their parents and their own perpetration of weapon violence against their siblings. Nearly one third of the sample (30.6%) reported having threatened a sibling with a knife at least once, whereas 9.9% reported having fired a gun at a sibling. In an unadjusted model, there was a significant association between interparental violence and weapon perpetration in this sample ($\beta = 0.24$), indicating that, on average, juvenile offenders who witnessed parental violence reported 0.24 more incidents of weapon perpetration against siblings than those without exposure to parental violence.

Casiano et al. (16) used data from the National Comorbidity Survey-Replication, a nationally representative sample of the United States, to show that about 13% of adults in the sample reported witnessing serious physical fights at home during childhood, whereas 3.5% reported threatening someone with a gun in adulthood, and 6.3% reported threatening someone with a weapon other than a gun. In adjusted logistic regression models, exposure to physical fights at home during childhood was associated with increased odds of weapon perpetration in adulthood, though the association was stronger for gun threats (aOR = 2.62, 95% CI: 1.8, 3.8) than for threats with another weapon (aOR = 1.34, 95% CI: 1.0, 1.8).

These studies represent a very small subset of the large body of literature that has examined the intergenerational transmission of violence, often termed the "cycle of violence," from a variety of disciplinary perspectives over the past 40 years (18, 19). Much of this work is not specific to gun or other weapon violence and therefore was excluded from our review; however, other reviews of this literature are available (18, 20, 21). Although work in this area has been beset by a number of methodological shortcomings (18, 20), these studies have generally found evidence of an association between childhood abuse or exposure to interparental violence during childhood and increased risk of violent or delinquent behaviors in adulthood, including abuse of one's own children and intimate partners (18, 20, 21). This work has been strengthened by a series of prospective investigations among children, including those with documented histories of abuse or neglect and comparable control groups, followed into adulthood, providing clearer evidence of the increased propensity of individuals maltreated in childhood to engage in violent and criminal behaviors (22–24) and to experience other negative consequences later in life, including IPV victimization (25, 26).

Violent victimization of a family member as a risk factor for individual perpetration. One additional study among adolescents from junior high schools in New York City (17) found that 41.5% of adolescents in the sample reported that a close friend or family member had been shot, and 19.4% reported having ever used a weapon on someone themselves. Gun victimization of a family member or close friend was associated with increased odds of weapon perpetration (odds ratio = 2.8, 95% CI: 2.1, 3.6). However, because this was a cross-sectional study, the temporal association between gun victimization of one's family member and weapon use could not be established. Therefore, this finding cannot distinguish between multiple possible explanations, including increased weapon carrying and use because of fear of victimization (27) or higher levels of gun-related behaviors among adolescents with other risks for violence exposure and delinquent behaviors in their families and broader social networks (28).

Violence transmission among intimate partners

We identified 6 studies that assessed the association between previous perpetration of gun or other weapon threats or use by an intimate partner and increased risk for reassault, homicide victimization, or homicide perpetration (11, 29–33). These studies used interviews and police records to identify occurrences of IPV, generally demonstrating that weapon use in the relationship serves as a powerful predictor of subsequent violence.

Violent perpetration by an intimate partner as a risk factor for individual perpetration. One study examined the role of prior gun violence in the relationship as a predictor of female-perpetrated homicide. Roberts (29) interviewed a sample of women incarcerated for killing their male partners and a control sample of abused women drawn from police department and women's shelter records and found that a greater proportion of incarcerated women reported that their abuser had used a gun against them (39.7% vs. 18.8% of the controls). The restriction of the homicide offenders to those incarcerated (thus excluding those who were acquitted or on probation) limits the inferences that can be drawn from this study, although other anecdotal studies have similarly suggested that weapon use in a relationship may spur homicide perpetration by victims in self-defense (29, 34, 35).

Violent perpetration by an intimate partner as a risk factor for individual victimization. A larger body of empirical studies has examined weapon perpetration by an intimate partner as a predictor of subsequent victimization. Campbell et al. (30) collected information from proxy respondents for a sample of femicide cases and from a sample of abused control women regarding their male abusers' previous threats with a weapon and gun use. Threats with a weapon were more common among the femicide cases than the controls (55.3% vs. 4.7%), as was gun use (38.2% vs. 0.9%), and both were found to be significantly associated with femicide versus control status in adjusted logistic regression models. In another study relying on interview data, Glass et al. (31) found that women whose partner or former partner had used a gun against them were 1.93 times more likely than abused women whose partner had not used a gun to experience reassault during a 1-month follow-up period, although this estimated association was not statistically significant (95% CI: 0.79, 4.75) given the relatively small size of the sample, which consisted of 84 women with a history of physical or sexual violence in the past year by a same-sex partner.

Three additional studies assessed the risk of reassault among individuals who had previously been victimized by their intimate partners, using police and court records to characterize initial and subsequent abuse incidents. Kingsnorth (32) followed heterosexual couples for 18 months after an IPV arrest and found that weapon use during the index event that prompted the arrest was associated with increased odds of physical violence recidivism during the follow-up period, even after considering sociodemographics and other characteristics of the index event (aOR = 2.14) ($P < 0.05$). Similarly, Bonomi et al. (33) followed couples for 2 years after a police-reported IPV incident perpetrated by a male against a female and found that weapon use during the index event was associated with 72% more physical violence victimization occurrences reported to the police during the follow-up period (95% CI: 1.29, 2.30). In contrast with these findings, Folkes et al. (11), using data collected from criminal records of male offenders, found that offenders' weapon threats or use during the index IPV incident, though associated with greater severity of that incident, were not associated with subsequent IPV recidivism. The use of police records restricts these studies to instances of serious violence that came to the attention of law enforcement, with the possibility that complete information about weapon use or subsequent victimization was not captured in police reports.

Despite these limitations, these studies are consistent with others reporting a progressive escalation of violence in intimate partner relationships, eventually culminating in threats with or use of a weapon and sometimes death (30, 36). Recent research also emphasizes the reciprocal nature of IPV, wherein the majority or near majority of couples report perpetration by both partners (37–40). Whether this mutual perpetration, including weapon use, reflects a defensive response to prior or concurrent victimization is sometimes hard to discern (41), but such reciprocal patterns of violence and retaliation often result in more severe injury than in relationships where non-reciprocal partner violence is the norm (40). These patterns may develop early, influenced by exposure to partner violence between parents in childhood (26, 37) and continuing through teen dating relationships, in which physical violence may be aggravated by weapon carrying and use (42).

Violence transmission among peers

Although a large body of research has examined the influence of delinquent peers on violent behaviors (43–45), much of this work uses general measures of delinquency and violence that encompass a wide range of behaviors, from drug use to physical fighting to weapon use. We identified only 1 study that looked specifically at the influence of peer physical violence perpetration on an adolescent's individual risk of weapon perpetration.

With regard to violent perpetration by a peer as a risk factor for individual perpetration, Haynie et al. (46) used data from the Add Health study to evaluate the associations between neighborhood characteristics and adolescent violence and whether exposure to violent and/or prosocial peers mediates these associations. During an initial in-school survey, Add Health participants nominated up to 10 friends (5 of each sex) from school rosters; these friends' self-reports of physical fighting were used to create a measure of exposure to violence in one's peer network. Participants later reported serious violent behaviors in the past 12 months (including threats or actual use of a knife or gun) during the wave II in-home interview. The authors found that a 1-standard deviation increase in peer fighting was associated with higher levels of weapon perpetration among adolescents ($\beta = 0.178$, standard deviation, 0.034) in adjusted hierarchical linear models. The use of peer-reported information on violence was a strength of this study, which concluded that residence in disadvantaged neighborhoods fostered association with violent peers, which in turn influenced risk of weapon perpetration.

Violence transmission within co-offending networks

Our systematic review identified 3 studies that specifically examined the influence of co-offending networks on violent gun victimization. These studies applied formal social network

analysis techniques to analyze the structure of co-offending networks and then correlate how observed network positions influenced individual risk of gun victimization, demonstrating that gun violence is highly concentrated in specific components of co-offending networks and that the social closeness of individuals in the network to gunshot victims significantly influences their own risk of violent gun victimization. These 3 studies were the only included studies that looked specifically at the transmission of gun violence within social networks.

In the first study, Papachristos et al. (8) used social network analysis to study all fatal and nonfatal gunshot injuries in a co-offending network of 763 individuals within Boston's Cape Verdean community. The co-offending network was constructed by first identifying the population of Cape Verdean gang members known to the Boston Police Department; these gang members were linked to their immediate associates and then their associates' associates through Field Interrogation Observation reports, representing noncustodial police contacts with and observations of individuals. The analysis revealed that roughly 85% of all gunshot victims were in a single network representing less than 5% of the Cape Verdean community's population. In adjusted logistic regression models, a greater percentage of immediate associates who were gunshot victims was associated with increased odds of individual gun victimization (aOR = 2.44, 95% CI: 1.11, 5.36). Further, each network association removed from another gunshot victim reduced the odds of gunshot victimization by 9% (aOR = 0.91, 95% CI: 0.84, 0.99).

In the second study, Papachristos and Wildeman (47) estimated the association of an individual's exposure to gun homicide in a co-offending network and the risk of individual gun homicide victimization across a high-crime African-American community of some 82,000 residents in a 6-square mile (15.54 km^2) area of Chicago, using the same exposure measure as Papachristos et al. (8). Co-offending networks were established by using Chicago Police Department data to determine instances where 2 or more people were arrested together for the same crime. The analysis showed that gun homicide victimization was highly concentrated within a single component containing less than 4% of the neighborhood's population but accounting for 41% of all gun homicides that occurred during the study time period. Logistic regression models showed that each social tie removed from a gun homicide victim decreased one's odds of being a gun homicide victim by about 58% (aOR = 0.42, 95% CI: 0.27, 0.65). Papachristos and Wildeman (47) concluded that network exposure to gun homicide was strongly associated with fatal gun victimization: The closer one is to a gun homicide victim, the greater the risk of fatal gun victimization.

The previous 2 studies relied on small samples and/or data for a single community. However, Papachristos et al. (48) used Chicago Police Department arrest data to analyze the entire co-offending population of Chicago in an effort to provide more accurate estimates of the true distribution of gun violence victimization risk in a large city. The resulting co-offending network comprised 169,725 unique individuals, representing approximately 6% of the total population of Chicago and 40% of all individuals arrested during this period. Nearly 70% of all nonfatal gun injuries were concentrated in this network of high-risk individuals during the study period. This study used an exposure term that measured the percentage of an individual's associates who were victims of gunshot wounds at various network distances (i.e., immediate associates, associates' associates, and so on). Results from logistic regression models revealed that, as an individual's exposure to gunshot victims increased, his/her own odds of victimization also increased. Papachristos et al. (48) estimated that every 1% increase in exposure to gunshot victims in one's immediate network increased the odds of victimization by roughly 1.1%, holding all else constant. By extension, if 10% or 50% of one's associates were victims, the odds of being shot increased by 12.1% or 76.9%, respectively, compared with someone with no associates who were victims.

Gang membership featured prominently in all 3 co-offending network studies. Briefly, these studies suggest that gang members may very well "pass on" violence within their networks via processes consistent with qualitative research on the norms of retaliation and respect among males in high-crime communities (5, 49, 50), with gangs and other delinquent groups exerting strong influence on violent offending and victimization, including gun carrying and use (51, 52). As a case in point, a recent study of gang networks in Chicago, Illinois, and Boston, Massachusetts, found that gang homicides are driven by norms of retaliation, organizational memory, status-seeking behaviors, and other network processes (53). Furthermore, the increased risk of violence among gang members may spread to non-gang members with whom they associate, as evidenced in a study using social network analysis techniques similar to those described above to document a co-offending network in Newark, New Jersey (54), in which social closeness to a gang member, defined through number of ties in the co-offending network, was strongly associated with a higher risk of gun victimization, reiterating the importance of network connections for risk of gun violence.

Gun carrying

Although it was not the main focus of our review, the importance of gun carrying continually emerged as a critical correlate of the transmission of gun violence, especially within the contexts of peer networks and urban street gangs. A large body of literature has assessed the correlates of gun-carrying behaviors, primarily among adolescents, including demographic, behavioral, and network influences, and has noted the important link between gun carrying and involvement in other types of gun violence, as well as the increased lethality of altercations between individuals when guns are involved (55, 56).

Although several studies have found that adolescents report fear of victimization and need for protection as their primary reason for carrying a gun or other weapon (27, 57), evidence for the role of previous and witnessed victimization in weapon carrying has been inconsistent (55, 58, 59). Some studies have found an association between the gun victimization of a close friend or family member with an adolescent's own gun carrying (17, 60, 61), whereas others have failed to find fear of victimization to be a convincing explanation of gun-carrying behaviors, especially when other network influences and aggressive tendencies are considered (58, 59, 62).

The gun-carrying behaviors of household members and peers, however, have been consistently found to correlate

strongly with individual gun-carrying behaviors (28, 55–58). This may represent a contagion effect, in which the perception of high levels of gun carrying among peers and classmates may lead adolescents to conclude that they also need to carry guns for protection, in turn leading to higher levels of gun carrying (58, 61, 63). Studies using formal network approaches have also found weapon carrying by relatives, peers, and associates to influence one's own gun carrying (27, 64), in contrast to possible selection processes, whereby individuals who have already adopted gun-carrying behaviors cluster together (64). Pro-weapon socialization by relatives and peers may thus be an important means of transmitting gun violence within networks. In addition, exposure to domestic violence perpetration during childhood may increase the risk of gun carrying (65, 66), which is in turn associated with IPV in dating relationships (42, 67, 68) and thus a potentially critical link between family violence exposure in childhood and perpetration of IPV later in life.

Gang involvement has also been closely linked with gun-carrying behaviors (58, 69). For instance, in their surveys of juvenile inmates and high school students, Sheley and Wright (70) found that 65% of inmate gang members and 30% of high school gang members owned a handgun compared with only 47% of nongang inmates and 11% of nongang students. In their 3-year field study of 99 active gang members, Decker and VanWinkle (71) found that 81% of their subjects owned guns and that two thirds had used the guns in gang conflicts, drive-by shootings, attacks against strangers, and other violent incidents. Consistent with these studies, a longitudinal analysis of 1,100 youth from around the United States found that, controlling for peer weapon carrying, subjects reporting gang membership were 220% more likely to carry hidden weapons than were nongang members (69).

Bjerregaard and Lizotte (51) found that Rochester, New York, gangs were more likely to recruit youth who already owned firearms. Further, compared with nongang members, gang members were much more likely to own a gun for protection, have peers who own a gun for protection, carry their guns outside the home, and be involved in gun-related crimes. Lizotte et al. (52) used panel data from an ongoing study of urban youth to demonstrate that gang membership was strongly associated with gun carrying during adolescence but, at older ages, drug dealing and illegal peer gun ownership replace gang membership as the primary determinants of illegal gun carrying.

Studies among gang members also confirm the powerful role of fear and the need for self-protection driving gun acquisition and carrying. Gang members acquire firearms because they believe their rivals have them, and they do not want to be caught at a disadvantage in local environments perceived to be highly dangerous (71–73). Among gang members and other youth involved in criminally active street networks, guns are also viewed as salient symbols of power and status and as a strategic means of gaining status, domination, or material goods (5). Gang members use guns to acquire and defend their status among their associates and rivals in their co-offending networks. Drawing from contagion perspectives on the proliferation of violence, Loftin (74) and Decker (75) suggest that, as guns are introduced into gang networks, more gang members arm themselves, guns are used to settle disputes and grievances, and more retaliatory gun violence results, thus escalating the deadliness and frequency of gang violence in many urban environments.

DISCUSSION

The results of our systematic review demonstrate that one's risk of violence, including victimization and perpetration of gun or other weapon violence, is increased through close connection with someone who has either perpetrated or been a victim of violence, with transmission demonstrated across family ties, intimate partner relationships, peer networks, and co-offending networks. Although not restricted to studies specifically using measures of gun violence as exposures and outcomes, this review shows that serious weapon-related violence can potentially arise from exposure to domestic violence in childhood, not just from delinquent and criminal activity among peers. Furthermore, the introduction of weapon violence into an intimate partner relationship signifies an increased risk of severe subsequent violence in that relationship. Taken together, the studies included in this review confirm the notion that gun violence has important origins in and consequences for networks of individuals, and future research must consider how connections between individuals promote or reduce the spread of gun violence in the population.

Given the observed patterns of intergenerational transmission of violence and reciprocal violence, our review suggests that gun and other weapon violence within intimate partner relationships is particularly hazardous, both for children who witness such perpetration in their households and for the victims and perpetrators of such violence. Studies utilizing formal network analysis indicate that increased risks of gun violence quickly decrease with increased distance from other victims, but such findings are derived mainly from the examination of co-offending networks. Further, findings from co-offending studies highlight the concentration of gun violence within particular high-risk subgroups and the need to disrupt processes of violence transmission within these groups. Studies of gun carrying in households, peer networks, and gangs confirm the central role of gun carrying as an important link in the transmission of gun violence within social networks.

Violence transmission mechanisms

The included studies provide insight into several potential mechanisms through which association with a victim or perpetrator of violence in one's social network influences one's own experiences of violence, including gun or other weapon violence. First, having a perpetrator of violence in one's network places individuals at direct risk of victimization by that perpetrator, as in the studies demonstrating that weapon perpetration by an intimate partner was one of the strongest predictors of subsequent victimization, including homicide, by that same partner (11, 30–33). Although not explicitly investigated in any of the studies included in our review, parent perpetration of violence against another adult household member is also highly correlated with child abuse (76), as an abusive adult often has multiple targets of violence in the home. These direct relations between a perpetrator and

victim represent the most obvious pathway through which network interactions influence victimization risk.

Second, in addition to direct victimization, close associations with a violent perpetrator increase vulnerability to victimization in other contexts, as in 2 of the included studies of victimization among children of violent parents (13, 14). This is a repeated finding in the violence literature, suggesting that individuals who are exposed to violence during childhood are likely to experience revictimization throughout their lives, potentially through acceptance of violence as the norm and the related development of "scripts" in which individuals assume the expected victim role (13) or through negative coping behaviors, such as alcohol and drug use, that may leave individuals prone to victimization (77–79).

Third, exposure to violent perpetration by a social network member has a strong influence on one's own propensity for violent perpetration. In the case of intergenerational transmission of violence, social or observational learning theory suggests that violent behaviors perpetrated by or between parents serve as a model for children's behavior and establish violence as a normative experience within families and relationships (80, 81). The included study by Murrell et al. (15) set out to test the role of specific learning or specialized transmission, in which individuals engage in the same behaviors they witnessed as children, by specifically assessing threatened or actual use of a gun or knife by the study respondents themselves and their parents. Although they did find evidence of an association between parents' weapon violence and the men's own weapon violence against an intimate partner, the association was small and the sample was limited to men who already had a history of domestic violence, limiting the inferences that can be drawn from this study; however, other studies have also found evidence of specific learning of violent behaviors (82). Social learning may also have played a role in the other included studies of weapon perpetration by individuals exposed to interparental violence (12, 16), as well as violence among peers (46). Besides social learning, studies of violence transmission within families have suggested that poor parental supervision and attachment, harsh parental discipline, accumulated traumatic experiences in childhood, poor psychosocial functioning and emotion dysregulation, early initiation of substance use, and early aggressive behaviors may serve as important links between family violence in childhood and later violent behaviors (24, 83–86).

Fourth, the violent victimization of a close social network member may predispose individuals to violent perpetration in retaliation or self-defense, as suggested by the literature on gang violence and on gun carrying referenced above. The study by Vaughanet al. (17) may be an example of this type of violence transmission, though more information would be needed about the timing of different violent behaviors to distinguish between alternate explanations. The study by Roberts (29) also reflects violence in self-defense, although other motivations for homicide perpetration by the women studied may also have been at play. Additionally, the spread of violence within co-offending networks in the included studies may reflect retaliatory processes (8, 47, 48), with the distinction between victims and perpetrators blurred as individuals get caught up in violence to avenge an injured or killed associate or act in self-defense (87).

Finally, high-risk behaviors shared by individuals in the same social network, including alcohol and drug use and other criminal and delinquent behaviors, may predispose connected individuals to share violent experiences, increasing risk for both perpetration and victimization, as in the studies of peer and co-offending networks (8, 46–48). We note that gun and other weapon access and carrying play a critical link in each of these types of network violence transmission, as illustrated in our brief narrative review of gun-carrying studies.

Limitations of existing studies of the transmission of violence

The studies of violence transmission reviewed here suffer from a number of methodological limitations. The majority of studies utilized cross-sectional (12–17) or case-control (29, 30) designs, including reliance on retrospective reports of violence exposure within networks. This severely limits our ability to draw inferences about the temporal associations between violence in one's network and one's own subsequent victimization or perpetration. Prospective study designs, in which recent violence exposure is measured at different points in time and related to subsequent violence in individuals, are needed to better elucidate the processes through which network exposure to violence influences individuals' own risk. Several included studies of IPV recidivism reflect examples of prospective designs, in which assault experiences were assessed during a follow-up period after first classifying participants by violence exposure at baseline (11, 31–33).

The data sources used to identify violence exposures and outcomes also introduce a number of limitations and potential biases into the reviewed studies. First, several studies relied on self-reports of both network violence exposure and experiences of individual victimization or perpetration (12–14, 16, 17, 31). Associations may be either under- or overestimated in these studies as a result of differential misclassification, in which individuals with violent outcomes may be more likely than those without such outcomes to under- or overreport their network violence exposure. Second, a number of studies utilized confirmed measures of individual violent outcomes (e.g., IPV, homicide) yet relied on self-reports of network violence exposures (15, 29, 30). For example, weapon threats or use against intimate partners was verified by court records in the study by Murrell et al. (15); however, parental weapon violence was self-reported by the men in the study, resulting in a noncomparable exposure measure and potentially leading to underestimates of this exposure or differential reporting influenced by the men's own violent behaviors. Similarly, Roberts (29) and Campbell et al. (30) both collected information on previous weapon threats or use by intimate partners; the abused control women in these studies may have been more reluctant than the cases to disclose such details of their relationships, particularly if they were still involved with the perpetrator. Furthermore, the use of proxy respondents by Campbell et al. (30) may have resulted in misclassification of previous weapon-related IPV among femicide cases, because the family members and friends who served as proxy respondents, although selected because of their knowledge of the relationship between the femicide victim and her partner, may not have been privy to these details.

In addition, studies relying on police reports to identify IPV incidents and create co-offending networks (8, 11, 31, 33, 47, 48) likely provide a conservative look at violence transmission within networks, as connections and violent incidents unknown to the police are not included. Finally, the network measures of violence exposure presented in several studies failed to specify the exact nature of the relation between the study respondent and the victim or perpetrator of violence in their network, utilizing language such as "family member" and "close friend" (17), which may be interpreted differently by different respondents and have different influences on violence risk. Specifying the exact relation of network members (e.g., parents vs. siblings), as well as the degree of connectedness (e.g., close friend vs. friend of a friend), and using data on violence collected directly from network members as in the study by Haynie et al. (46) may shed further light on the connections that most increase risk of violence. The increasing use of formal network analysis to study the transmission of violence holds promise for clarifying these risks and relevant points of intervention within networks, but it requires new types of data collection and study design.

We found the literature on the transmission of gun violence within social networks to be disappointingly scarce, with only 3 of the included studies specifically examining the risk of individual gun violence associated with gun violence in one's social network and all 3 of these studies focusing on co-offending networks. Although the other included studies provided additional clues to the generation and consequences of gun violence within other types of networks, many of them utilized measures of "weapon" use, including firearms along with other types of weapons like knives (12–15, 17, 32, 33, 46). Although the carrying and use of a broad array of weapons bring increased risks of violence worth noting (58, 59), the particular lethality of firearms, along with their less frequent usage compared with other weapons, suggests that distinguishing them from other types of weapons is important for identifying individuals who may be at greatest risk for lethal violence. Furthermore, several studies failed to distinguish between weapon threats and actual weapon use (15, 16, 31), which also has important implications for the severity of violence.

The reliance on restricted populations in several of the included studies limits our ability to generalize the findings to other groups or the population more broadly. Three of the included studies among adolescents used school-based samples (13, 17, 46), which may exclude youth who have dropped out of school and are at perhaps even greater risk for gun violence (61, 63, 67); others relied on samples with a history of violence (11, 12, 15, 29–33), which may display unique patterns of weapon behaviors relative to individuals without a history of violence. Studies also largely failed to consider differential estimated effects of network violence exposure across different subgroups of the population, defined by sex, age, or urbanicity, despite evidence that violence exposure may have different outcomes for different groups (81).

Finally, although most of the included studies considered potential confounders of the relation between network violence exposure and one's own violent behaviors, the range of confounders considered varied widely, and few studies explicitly investigated potential mediators of the observed relations. Several studies provided only simple unadjusted comparisons of violence among individuals with and without a connection to a victim or perpetrator (11, 12, 15, 17, 29, 31), leaving open the possibility that observed associations could be explained by other correlates of both the exposure and outcome. However, the majority included a variety of potential confounders in adjusted models, including sociodemographic characteristics of the participants and/or their parents (8, 13, 14, 16, 30, 32, 33, 46–48); other previous violence experiences, such as childhood neglect, sexual abuse, or other prior victimization (13, 16, 46); measures of parenting quality and parent-child relationships (14, 46); lifetime mental disorders (16); characteristics of the relationship between the victim and perpetrator and prior violent incidents (30, 32, 33); other network characteristics, such as network size and presence of gang members (8, 47, 48); and neighborhood characteristics, such as income and residential stability (33, 46). These studies generally did not specify hypothesized pathways from network violence exposure to individual violence risk, failing to distinguish between potential mediators and confounders. Although the finding of a positive association between network violence exposure and individual violence was generally upheld even when adjusting for other covariates, the causal nature of the association cannot be inferred from these observational studies without additional assumptions. Improved data collection on potential confounders and mediators, preferably utilizing a prospective study design, will be needed to advance our understanding of the mechanisms connecting exposure to gun violence in one's network to one's own gun violence risk (24, 82). More advanced analytical techniques, including complex systems modeling approaches, can also be utilized to test alternate theories about the transmission of gun violence within networks, similar to models applied to infectious disease transmission processes (88, 89), and to identify and test causal models of violence transmission.

It should also be noted that our review itself was subject to the limitations of any systematic review, especially our inclusion of only a restricted number of databases and our application of eligibility criteria that may have excluded other potentially relevant studies.

Implications for interventions

Identifying and disrupting the spread of gun and other weapon violence within high-risk networks hold great potential for reducing the burden of violence and its consequences in the population. Our review suggests that children exposed to violence in their households, including domestic violence disputes or the gun victimization of a family member, should be targeted for interventions aimed at improving psychosocial functioning, reducing behavioral problems, and learning conflict resolution strategies that do not involve violence; these children may be identified by police or family courts investigating domestic violence incidents or through services offered in women's shelters (24). Adult household members may also benefit from parenting and conflict resolution training, for example, through home visitation programs, whether they are living in a household prone to domestic conflict (24) or in areas where gun violence is common (90). Similarly, women or men who have been the victim of threats or use of

a gun or other weapon by an intimate partner are in need of intervention to prevent further escalation of violence. Healthcare practitioners should question individuals not only about domestic violence but also about abusers' access to a gun (30) and should provide appropriate referrals to services and information regarding serious risks in such situations (31).

Research on violence exposure within co-offending networks provides unique insights that might be leveraged for more effective gun violence prevention efforts. In particular, network graphing techniques, as well as potential risk-assessment models, might be used to identify individuals occupying especially vulnerable positions within networks and to direct resources and intervention efforts accordingly. Interventions in Boston (91) and Cincinnati, Ohio (92), have already begun using network analysis to identify potential high-risk gangs as part of violence prevention efforts and have produced statistically significant reductions in gun violence. For example, a recent quasi-experimental evaluation of a gang violence reduction program in Boston found a 31% reduction in shootings among gangs targeted by the program as compared with similar gangs within the city (93). Insights from the co-offending models reviewed here imply that similar efforts targeted at individuals within networks have great potential for reducing gun violence.

In conclusion, this review identified 16 articles that highlight the important role of exposure to violence in one's social network as a risk factor for individual victimization and perpetration, confirming the spread of violence through varied network connections, including families, romantic relationships, peers, and co-offenders. Further research on the transmission of gun violence specifically and on the exact mechanisms through which the spread of gun violence occurs within networks is needed to fully understand how these transmission processes can be most effectively disrupted.

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REFERENCES

1. National Center for Injury Prevention and Control, Centers for Disease Control and Prevention. Web-based injury statistics query and reporting system. http://www.cdc.gov/injury/wisqars/facts.html. Published August 20, 2014. Updated August 12, 2015. Accessed August 19, 2015.
2. Institute of Medicine, National Research Council. *The Future of Public Health*. Washington, DC: National Academy of Sciences Press; 1988.
3. Institute of Medicine, National Research Council. *Priorities for Research to Reduce the Threat of Firearm-Related Violence*. Washington, DC: National Academies Press; 2013.
4. National Research Council. *Firearms and Violence*. Washington, DC: National Academies Press; 2005.
5. Fagan J, Wilkinson D. Guns, youth violence, and social identity in inner cities. *Crime Justice*. 1998;24:105–188.
6. Sharkey P. The acute effect of local homicides on children's cognitive performance. *Proc Natl Acad Sci U S A*. 2010; 107(26):11733–11738.
7. Valente TW. Network interventions. *Science*. 2012;337(6090): 49–53.
8. Papachristos AV, Braga AA, Hureau DM. Social networks and the risk of gunshot injury. *J Urban Health*. 2012;89(6):992–1003.
9. Smith KP, Christakis NA. Social networks and health. *Annu Rev Sociol*. 2008;34:405–429.
10. Tsai AC, Papachristos AV. From social networks to health: Durkheim after the turn of the millennium. Introduction. *Soc Sci Med*. 2015;125:1–7.
11. Folkes SE, Hilton NZ, Harris GT. Weapon use increases the severity of domestic violence but neither weapon use nor firearm access increases the risk or severity of recidivism. *J Interpers Violence*. 2013;28(6):1143–1156.
12. Khan R, Cooke DJ. Risk factors for severe inter-sibling violence: a preliminary study of a youth forensic sample. *J Interpers Violence*. 2008;23(11):1513–1530.
13. Murphy LM. Childhood and adolescent violent victimization and the risk of young adult intimate partner violence victimization. *Violence Vict*. 2011;26(5):593–607.
14. Tucker CJ, Finkelhor D, Turner H, et al. Family dynamics and young children's sibling victimization. *J Fam Psychol*. 2014; 28(5):625–633.
15. Murrell AR, Merwin RM, Christoff KA, et al. When parents model violence: the relationship between witnessing weapon use as a child and later use as an adult. *Behav Soc Issues*. 2005; 14(2):128–133.
16. Casiano H, Mota N, Afifi TO, et al. Childhood maltreatment and threats with weapons. *J Nerv Ment Dis*. 2009;197(11): 856–861.
17. Vaughan RD, McCarthy JF, Armstrong B, et al. Carrying and using weapons: a survey of minority junior high school students in New York City. *Am J Public Health*. 1996;86(4):568–572.
18. Widom CS. Does violence beget violence? A critical examination of the literature. *Psychol Bull*. 1989;106(1):3–28.
19. Fagan AA. The relationship between adolescent physical abuse and criminal offending: support for an enduring and generalized cycle of violence. *J Fam Violence*. 2005;20(5):279–290.
20. Ertem IO, Leventhal JM, Dobbs S. Intergenerational continuity of child physical abuse: how good is the evidence? *Lancet*. 2000;356(9232):814–819.
21. Stith SM, Rosen KH, Middleton KA, et al. The intergenerational transmission of spouse abuse: a meta-analysis. *J Marriage Fam*. 2000;62(3):640–654.
22. Widom CS. The cycle of violence. *Science*. 1989;244(4901): 160–166.
23. Maxfield MG, Widom CS. The cycle of violence. Revisited 6 years later. *Arch Pediatr Adolesc Med*. 1996;150(4):390–395.
24. Fergusson DM, Boden JM, Horwood LJ. Developmental antecedents of interpartner violence in a New Zealand birth cohort. *J Fam Violence*. 2008;23(8):737–753.

25. Widom CS, Czaja S, Dutton MA. Child abuse and neglect and intimate partner violence victimization and perpetration: a prospective investigation. *Child Abuse Negl*. 2014;38(4): 650–663.
26. Ehrensaft MK, Cohen P, Brown J, et al. Intergenerational transmission of partner violence: a 20-year prospective study. *J Consult Clin Psychol*. 2003;71(4):741–753.
27. Arria A, Borges G, Anthony JC. Fears and other suspected risk factors for carrying lethal weapons among urban youths of middle-school age. *Arch Pediatr Adolesc Med*. 1997;151(6): 555–560.
28. Myers GP, McGrady GA, Marrow C, et al. Weapon carrying among black adolescents: a social network perspective. *Am J Public Health*. 1997;87(6):1038–1040.
29. Roberts AR. Battered women who kill: a comparative study of incarcerated participants with a community sample of battered women. *J Fam Violence*. 1996;11(3):291–304.
30. Campbell JC, Webster D, Koziol-McLain J, et al. Risk factors for femicide in abusive relationships: results from a multisite case control study. *Am J Public Health*. 2003;93(7):1089–1097.
31. Glass N, Perrin N, Hanson G, et al. Risk for reassault in abusive female same-sex relationships. *Am J Public Health*. 2008; 98(6):1021–1027.
32. Kingsnorth R. Intimate partner violence: predictors of recidivism in a sample of arrestees. *Violence Against Women*. 2006;12(10):917–935.
33. Bonomi AE, Trabert B, Anderson ML, et al. Intimate partner violence and neighborhood income: a longitudinal analysis. *Violence Against Women*. 2014;20(1):42–58.
34. Browne A. *When Battered Women Kill*. New York, NY: The Free Press; 1987.
35. Walker LE. *The Battered Woman Syndrome*. New York, NY: Springer Publishing Co; 1984.
36. Hines DA, Douglas EM. Predicting potentially life-threatening partner violence by women toward men: a preliminary analysis. *Violence Vict*. 2013;28(5):751–771.
37. Field CA, Caetano R. Longitudinal model predicting mutual partner violence among white, black, and Hispanic couples in the United States general population. *Violence Vict*. 2005; 20(5):499–511.
38. Foshee VA, Benefield TS, Reyes HL, et al. The peer context and the development of the perpetration of adolescent dating violence. *J Youth Adolesc*. 2013;42(4):471–486.
39. Harned MS. A multivariate analysis of risk markers for dating violence victimization. *J Interpers Violence*. 2002;17(11): 1179–1197.
40. Whitaker DJ, Haileyesus T, Swahn M, et al. Differences in frequency of violence and reported injury between relationships with reciprocal and nonreciprocal intimate partner violence. *Am J Public Health*. 2007;97(5):941–947.
41. Herrera VM, Wiersma JD, Cleveland HH. The influence of individual and partner characteristics on the perpetration of intimate partner violence in young adult relationships. *J Youth Adolesc*. 2008;37(3):284–296.
42. Howard DE, Debnam KJ, Wang MQ, et al. 10-year trends in physical dating violence victimization among U.S. adolescent males. *Int Q Community Health Educ*. 2011;32(4):283–305.
43. Akers R. *Social Learning and Social Structure: A General Theory of Crime and Deviance*. Boston, MA: Northeastern University Press; 1998.
44. Haynie DL. Delinquent peers revisited: Does network structure matter? *Am J Sociol*. 2001;106(4):1013–1057.
45. Thornberry TP, Lizotte AJ, Krohn MD, et al. Delinquent peers, beliefs, and delinquent behavior: a longitudinal test of interactional theory. *Criminology*. 1993;32(1):47–83.
46. Haynie DL, Silver E, Teasdale B. Neighborhood characteristics, peer networks, and adolescent violence. *J Quant Criminol*. 2006;22(2):147–169.
47. Papachristos AV, Wildeman C. Network exposure and homicide victimization in an African American community. *Am J Public Health*. 2014;104(1):143–150.
48. Papachristos AV, Wildeman C, Roberto E. Tragic, but not random: the social contagion of nonfatal gunshot injuries. *Soc Sci Med*. 2015;125:139–150.
49. Anderson E. *Code of the Streets*. New York, NY: Norton; 1999.
50. Jacobs BA, Wright R. *Street Justice: Retaliation in the Criminal Underworld*. New York, NY: Cambridge University Press; 2006.
51. Bjerregaard B, Lizotte AJ. Gun ownership and gang membership. *J Crim Law Criminol*. 1995;86(1):37–58.
52. Lizotte AJ, Krohn MD, Howell JC, et al. Factors influencing gun carrying among young urban males over the adolescent-young adult life course. *Criminology*. 2000;38(3): 811–834.
53. Papachristos AV, Hureau DM, Braga AA. The corner and the crew: the influence of geography and social networks on gang violence. *Am Sociol Rev*. 2013;78(3):417–447.
54. Papachristos AV, Braga AA, Piza E, et al. The company you keep? The spillover effects of gang membership on individual gunshot victimization in a co-offending network. *Criminology*. 2015;53(4):624–649.
55. Steinman KJ, Zimmerman MA. Episodic and persistent gun-carrying among urban African-American adolescents. *J Adolesc Health*. 2003;32(5):356–364.
56. Sheley JF, McGee ZT, Wright JD. Gun-related violence in and around inner-city schools. *Am J Dis Child*. 1992;146(6): 677–682.
57. Simon TR, Crosby AE, Dahlberg LL. Students who carry weapons to high school: comparison with other weapon-carriers. *J Adolesc Health*. 1999;24(5):340–348.
58. Cao L, Zhang Y, He N. Carrying weapons to school for protection: an analysis of the 2001 school crime supplement data. *J Crim Justice*. 2008;36(2):154–164.
59. Rountree PW. Weapons at school: Are the predictors generalizable across context? *Sociol Spectr*. 2000;20(3): 291–324.
60. Molnar BE, Miller MJ, Azrael D, et al. Neighborhood predictors of concealed firearm carrying among children and adolescents: results from the Project on Human Development in Chicago neighborhoods. *Arch Pediatr Adolesc Med*. 2004; 158(7):657–664.
61. Hemenway D, Prothrow-Stith D, Bergstein JM. Gun carrying among adolescents. *Law Contemp Probl*. 1996;59(1):39–53.
62. Webster DW, Gainer PS, Champion HR. Weapon carrying among inner-city junior high school students: defensive behavior vs aggressive delinquency. *Am J Public Health*. 1993; 83(11):1604–1608.
63. Hemenway D, Vriniotis M, Johnson RM, et al. Gun carrying by high school students in Boston, MA: Does overestimation of peer gun carrying matter? *J Adolesc*. 2011;34(5):997–1003.
64. Dijkstra JK, Lindenberg S, Veenstra R, et al. Influence and selection processes in weapon carrying during adolescence: the roles of status, aggression, and vulnerability. *Criminology*. 2010;48(1):187–220.
65. Yexley M, Borowsky I, Ireland M. Correlation between different experiences of intrafamilial physical violence and violent adolescent behavior. *J Interpers Violence*. 2002;17(7): 707–720.
66. Abrahams N, Jewkes R. Effects of South African men's having witnessed abuse of their mothers during childhood on their

levels of violence in adulthood. *Am J Public Health*. 2005; 95(10):1811–1816.
67. Kodjo CM, Auinger P, Ryan SA. Demographic, intrinsic, and extrinsic factors associated with weapon carrying at school. *Arch Pediatr Adolesc Med*. 2003;157(1):96–103.
68. Howard DE, Beck K, Kerr MH, et al. Psychosocial correlates of dating violence victimization among Latino youth. *Adolescence*. 2005;40(158):319–331.
69. Melde C, Esbensen F, Taylor TJ. 'May piece be with you': a typological examination of the fear and victimization hypothesis of adolescent weapon carrying. *Justice Q*. 2009; 26(2):348–376.
70. Sheley JF, Wright JD. *In the Line of Fire: Youth, Guns, and Violence in Urban America*. New York, NY: Aldine de Gruyter; 1995.
71. Decker S, VanWinkle B. *Life in the Gang*. New York, NY: Cambridge University Press; 1996.
72. Short JF, Strodbeck FL. *Group Process and Gang Delinquency*. Chicago, IL: University of Chicago Press; 1965.
73. Horowitz R. *Honor and the American Dream*. New Brunswick, NJ: Rutgers University Press; 1983.
74. Loftin C. Assaultive violence as a contagious social process. *Bull N Y Acad Med*. 1986;62(5):550–555.
75. Decker SH. Collective and normative features of gang violence. *Justice Q*. 1996;13(2):243–264.
76. Herrenkohl TI, Sousa C, Tajima EA, et al. Intersection of child abuse and children's exposure to domestic violence. *Trauma Violence Abuse*. 2008;9(2):84–99.
77. Chu JA. The revictimization of adult women with histories of childhood abuse. *J Psychother Pract Res*. 1992;1(3): 259–269.
78. Desai S, Arias I, Thompson MP, et al. Childhood victimization and subsequent adult revictimization assessed in a nationally representative sample of women and men. *Violence Vict*. 2002; 17(6):639–653.
79. Fergusson DM, Horwood LJ, Lynskey MT. Childhood sexual abuse, adolescent sexual behaviors and sexual revictimization. *Child Abuse Negl*. 1997;21(8):789–803.
80. Bandura A. *Social Learning Theory*. Englewood Cliffs, NJ: Prentice Hall; 1977.
81. Fang X, Corso PS. Gender differences in the connections between violence experienced as a child and perpetration of intimate partner violence in young adulthood. *J Fam Violence*. 2008;23(5):303–313.
82. Besemer S. Specialized versus versatile intergenerational transmission of violence: a new approach to studying intergenerational transmission from violent versus non-violent fathers: latent class analysis. *J Quant Criminol*. 2012;28(2): 245–263.
83. Dube SR, Anda RF, Felitti VJ, et al. Exposure to abuse, neglect, and household dysfunction among adults who witnessed intimate partner violence as children: implications for health and social services. *Violence Vict*. 2002;17(1):3–17.
84. Gratz KL, Paulson A, Jakupcak M, et al. Exploring the relationship between childhood maltreatment and intimate partner abuse: gender differences in the mediating role of emotion dysregulation. *Violence Vict*. 2009;24(1):68–82.
85. Iverson KM, McLaughlin KA, Adair KC, et al. Anger-related dysregulation as a factor linking childhood physical abuse and interparental violence to intimate partner violence experiences. *Violence Vict*. 2014;29(4):564–578.
86. Marganski A. Adult attachment as a criminological construct in the cycle of violence. *Violence Vict*. 2013;28(2):210–232.
87. Spano R, Bolland J. Disentangling the effects of violent victimization, violent behavior, and gun carrying for minority inner-city youth living in extreme poverty. *Crime Delinq*. 2013; 59(2):191–213.
88. Fonoberova M, Fonoberov VA, Mezic I, et al. Nonlinear dynamics of crime and violence in urban settings. *J Artif Soc Soc Simul*. 2012;15(1):2.
89. Smith LM, Bertozzi AL, Brantingham PJ, et al. Adaptation of an ecological territorial model to street gang spatial patterns in Los Angeles. *Discrete Contin Dyn Syst*. 2012;32(9): 3223–3244.
90. Kellermann AL, Fuqua-Whitley DS, Rivara FP, et al. Preventing youth violence: what works? *Annu Rev Public Health*. 1998;19:271–292.
91. Kennedy DM, Braga AA, Piehl AM. The (un)known universe: mapping gangs and gang violence in Boston. In: Weisburd D, McEwen JT, eds. *Crime Mapping and Crime Prevention*. Monsey, NY: Criminal Justice Press; 1997:219–262.
92. Engel RS, Tillyer MS, Corsaro N. Reducing gang violence using focused deterrence: evaluating the Cincinnati initiative to reduce violence (CIRV). *Justice Q*. 2013;30(3):403–439.
93. Braga AA, Hureau DM, Papachristos AV. Deterring gang-involved gun violence: measuring the impact of Boston's operation ceasefire on street gang behavior. *J Quant Criminol*. 2014;30(1):113–139.